Microchannel Reactor System for Catalytic Hydrogenation

Energy-Efficient Catalytic Hydrogenation Reactions

Hydrogenation reactions are very versatile and account for 10% to 20% of all reactions in the pharmaceutical industry. However, they are highly exothermic, generating large quantities of heat that must be removed or recovered. Ineffective heat removal can result in reactor performance degradation and even in thermal runaway conditions with the possibility for explosion. New, energy-efficient microchannel reactors hold potential to significantly improve the efficiency and safety of catalytic-hydrogenation manufacturing processes. These reactors possess small transverse dimensions with high surface-to-volume ratios and consequently exhibit enhanced heat and mass-transfer rates.

Stevens Institute of Technology in partnership with Bristol-Meyers Squibb, ChemProcess Technologies, LLC, the New Jersey Nanotechnology Consortium, Information by Design, and the New Jersey Commission on Science and Technology, will demonstrate the benefits of a novel process intensification concept for catalytic hydrogenation reactions by employing microchannel reactors. The novel reactor concept has the potential to save significant amounts of steam and electricity now used to drive catalytic hydrogenation processes. In addition, the reactor design could improve yield, reduce feedstock requirements, and lower generation of waste and byproducts.

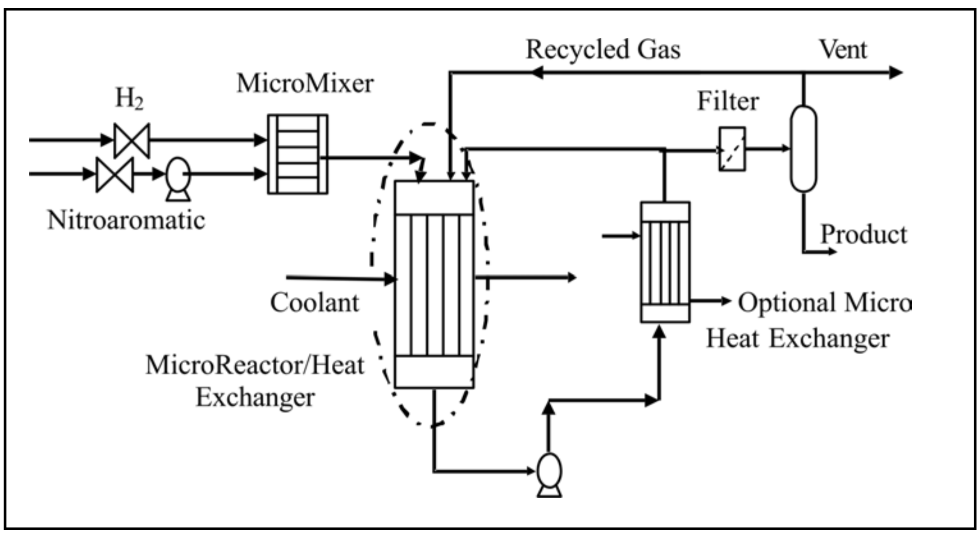

Fig. 1: Proposed microchannel reactor-based process intensification system

Benefits

By 2020:

- *Energy savings in excess of 20 trillion Btu per year*
- *70% steam, 90% electricity, and 10% feedstock savings*
- *70% waste savings*

Applications

The use of microchannel reactors for catalytic hydrogenation reactions has the potential to improve a significant number of hydrogenation reactions in both the chemical and pharmaceutical industries.

Project Partners

- *Stevens Institute of Technology.*
- *New Jersey Commission on Science and Technology*
- *Bristol-Meyers Squibb*
- *ChemProcess Technologies, LLC*
- *New Jersey Nanotechnology Consortium*
- *Information by Design*

Project Description

Goal: The goal of the first 3-year phase is to design, fabricate, evaluate, and optimize a laboratory-scale microchannel reactor/heat exchanger system with thin-film catalysts for hydrogenation of p-nitrochlorobenzene and o-nitroanisole under moderate temperature and pressure. In the 2-year second phase, the team will demonstrate industrial pilot-plant scale catalytic hydrogenation as a prelude to commercialization of the technology.

At the pre-commercial stage, the microchannel reactor system will consist of a single microreactor scheme, which on a large scale will involve an appropriate increase in the number of bundled/stacked microchannel plates. The catalyst will be developed and deposited on the microchannel wall as a thin film. Through the use of the microreactor concept, effective temperature control, high active catalyst surface area, and enhanced heat and mass transfer will allow for operations at high H2 concentrations.

Activities: To resolve the technical challenges and accomplish the project goals, the team has formulated a set of tasks for phase 1 and 2. Tasks for the first phase include: (1) experimental laboratory reactor system design, fabrication, and initial evaluation, (2) multifunctional thin-film catalyst development, (3) microreactor fabrication and microarray kinetic evaluation, (4) model-based concept microreactor design and demonstration, (5) laboratory reactor system optimization, and (6) production plant design. Task (7) will be conducted in the second phase of the project, and will focus on reactor system analysis, optimization, integration, and evaluation. The second phase of the project will only take place after passing a go/no-go decision point based on the outcomes of phase 1, as measured by yield, energy efficiency, ease of operation, and reliability.

Progress and Milestones

Tasks 1-6 will take place in the first three years. Based on the review of the go/no-go criteria, if the proposed concept is found to be technically feasible and projected to be economically viable, task 7 will be undertaken as phase 2 at the Bristol-Meyers Squibb site.

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